13

Use of RFID tags for data storage on quality control in cheese industries

Raquel Pérez-Aloe[1], José M. Valverde[1], Antonio Lara[1], Fernando Castaño[1], Juan M. Carrillo[1], José González[2] and Isidro Roa[2]
Universidad de Extremadura[1]. Instituto Tecnológico Agroalimentario[2]
Spain

1. Introduction

The current laws that regulate the food security in the European Union lay down the principles and general requirements of the food legislation. In the article 3 of the Regulation 178/2002 the traceability is defined as the "ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution". In addition, "the food traceability must be guaranteed in all the stages described above: production, transformation and distribution" which implies the obligation of being able of identifying every product in the company providing a complete information about it (Regulation 178, 2002).

Depending on the activity in the food chain three different types of traceability can be distinguished:

1) Back traceability, called *"suppliers traceability"* as well, refers to the possibility of having knowledge of what products are coming into the company, where are they coming from as well as which farmers are their suppliers.
2) Internal traceability or *"process traceability"* refers to the information about what is made, from what it is made, how and when it is made and the identification of the product.
3) Forward traceability or *"client traceability"* means the possibility of knowing what products the company delivers, when and to whom they have been supplied (Coscarón et al. 2007; Spanish Agency for Food Security, 2004).

Although the law imposes a generic obligation of traceability, it is not mentioned the way in which companies can achieve that goal (Decree 1808, 1991; Decree 217, 2004).

Nowadays, the sector of cheese production has no a procedure that exhaustively guarantees a proper traceability throughout all the fabrication stages. The main problem is the cheese ripening, done in special chambers as shown in Figure 1. The surrounding conditions in these rooms, such as humidity, temperature, product handling (turning), mould and flora growing avoid the individual labeling of the products. Is for this that the production and quality control are performed by batches and the data storage of the information is done manually by the company staff.

Moreover, if the cheese produced by a specific manufacturer has a Protected Denomination of Origin (P.D.O.) then the product must satisfy stringent requirements about the milk (origin, characteristics and preserving) and the elaboration, ripening and physical and physicochemical characteristics of the final result.

Fig. 1. A traditional ripening chamber

To have an idea, for example, the "Ibores" cheese (Spanish Southwest P.D.O.) has to be made with milk of mountain goats, with a preservation temperature less than 6º C, a minimum protein content of 6%, fat around 4%, pH higher than 6,5 and so on. One of the elaboration steps is the salting , which can be wet or dry, using only sodium chloride. In case of wet salting, the maximum stay time shall be 24 hours in a saline solution with a maximum concentration of 20%. Regarding the ripening time, it should be, at least, sixty days, being the finished product cylindrical with a height from 6 to 9 cm, diameter comprised between 12 and 15 cm and a weight from 750 to 1200 g. In the most traditional presentation, the cheese is coated with paprika or smeared with olive oil, appearing diverse colorations due to different moulds (Order 25/4, 1997). This is only a brief summary of the conditions that "Ibores" cheeses should meet in order to be qualified as product with P.D.O. The agency responsible for accrediting the P.D.O. is the Regulatory Board. Usually a technical expert visits the cheese industry requesting to the manufacturer a collection of data corresponding to the elaboration process to certify, if appropriate, the guarantee of origin and quality. Besides, the Regulatory Boards of P.D.O. are recognized as entities of product certification according to the European Standard EN 45011. This regulation shows in detail the criteria to be applied by these entities to perform a certification of products reliable and transparent. For instance, in the document that details the criteria to be evaluated by the technical staff of the Regulatory Board of P.D.O. "Torta del Casar", other Spanish Southwest P.D.O. (Order 11/1, 1999; Order 9/10, 2001; Order 6/5, 2002; Regulation 1491, 2003), appears that the Regulatory Board lays down a control based on sampling and analysis of milk and cheese. The results will be used in the development of a set of measurable data which will serve as basis for the accreditation process and to verify the adequacy of the dairy industry to the certification system. This system, in fact, is based on a procedure of self-control that includes several actions to be done by the person in charge of quality

control in the company. These actions must be the periodic checking, as determined by the regulations, of the physical, physicochemical, microbiological and organoleptic parameters of the batches to be issued to the market, having a record of the results (CC/3, 2005; CC/4, 2007).

As it is clear from above, it is desirable that the cheese industry and the Regulatory Board of P.D.O. interact effectively and efficiently to achieve that the final product reaches the consumer with full guarantee of its origin, manufacturing process or quality. Therefore the main objective here will be to join efforts between the dairy companies, in terms of traceability, and the Regulatory Boards of P.D.O. with respect to their quality systems to certificate products. In this way, the binomial Company-Regulatory Board would have the necessary tools (hardware-software) that would enable compliance with current legislation regarding traceability, as well as a continuous quality improvement thanks to the optimization of the technological process according to the information obtained, respectively. The key points here would be the speed on getting the required information, the time saved and the simplification of tasks that would provide the implemented tool compared to the manual records of data usually done by both, the employees of the cheese industry and the technical staff of the Regulatory Board of P.D.O. in charge of the quality certification.

To achieve this goal, a system which deals with the use of Radio Frequency IDentification (RFID) has been developed. The RFID is a contactless method for data transfer in object identification. The transmission of data is carried-out through electromagnetic waves. The tag (transponder) consists of a microchip, as well as an antenna, which are usually put in some form of casing for protection against different environments. The RFID read/write device creates a weak electromagnetic field. If a RFID tag passes this field, the microchip of the transponder wakes up and can send or receive data without any contact to the reader. If the tag leaves the field, the communication gets interrupted and the chip on the tag stops working, but the data on the tag keeps stored (Finkenzeller, 2003). To provide the system with portability a PDA (Personal Digital Assistant) with reader and embedded antenna can be used. Figure 2 shows the usual components of a RFID system.

Fig. 2. Usual components of a RFID system

There are different RFID technologies available: passive tags have no own power source and take their energy directly from the magnetic field of the reader. Passive RFID tags do not need any maintenance, but the reading distance depends on the size and frequency of the transponder and antenna. Active tags are much more complex than passive tags and have an internal battery to increase the reading distances. The life time of active tags is limited through the battery. The semi-passive tags contain a power source, such as a battery, to power the microchip's circuitry. Unlike active tags, semi-passive tags do not use the battery to communicate with the reader. Communication is done in the same manner than passive tags do. Semi-passive tags might be dormant until activated by a signal from a reader. This conserves battery power and can lengthen the life of the tag. There are systems with 134 kHz, 125 kHz, 13.56 MHz, 868 MHz, 915 MHz, 2.45 GHz available, having different properties and reading distances depending on the environmental conditions.
Hence the main characteristics of a RFID system are:
- Communication done without physical contact between the reader and the tags.
- Soil resistant.
- No line of sight required.
- Read/Write memory.
- Possibility to store production and/or product data into the tag´s memory.
- Multi read /write capability.

Obviously, the use in dairy products of these "smart cards or tags" allows obtaining the benefits that come from the fact of providing the product with a "certain kind of intelligence", such as:
- To have only one identity.
- To be able to communicate with his environment in a efficient way.
- To be capable of obtaining and retaining the information about itself.

Also in this context, the RFID solution offers, versus the „traditional" bar code, the following advantages:
- Huge number of data in a reduced physical space.
- Automatic writing/reading in either individual or by batch mode. This is performed thanks to the use of anti-collision algorithms, which allow reading several RFID tags without interferences.
- Bar code needs visibility to work properly and the information stored can not be changed using the same tag.
- Bar code identifies a type of object. The RFID tag identifies an only object in an only way.
- Bar code is easily damaged in wet environments like are the ripening chambers where mould growing exists. In this case a RFID tag can be wrapped, for example, by *biofilm* without affecting the reading/writing process.

Barcodes are of course cheap to create, but they are limited in their storage capacity and are not flexible, when data needs to be changed.
Taking into account all the features mentioned above, a system based on the use of RFID transponders seems to be the most appropriate to carry-out the proposed tasks. The idea is to use RFID tags as physical support for storing the information required to perform a "complete traceability" in cheese industries, as well as facilitate the collection of data required by the technical experts of the Regulatory Boards in charge of quality certification (Pérez-Aloe et al., 2007). The application will perform the three types of traceability (vendor, process and customer) and an individual register of analysis and controls done in all the

production stages (milk reception, storage, fabrication, ripening, quality and yield control and pH measures) as well. In this way, the collected data corresponding to the process conditions (humidity, temperature, pressure, ventilation) including microorganism, biochemical and pH analysis and the connection of these data with the products provided by the different suppliers are increased. Then, the traceability will be granted, both on batches and on individual cheeses. This contributes to assure and certificate the quality, making easier the location, immobilization and in some cases the effective and selective recall when problems arise.
In this way, the device RFID would operate as an interface making easier and more efficient the exchange of data and information between the company and the technical staff of the Regulatory Board of the P.D.O. A sketch of this procedure can be seen in Figure 3.

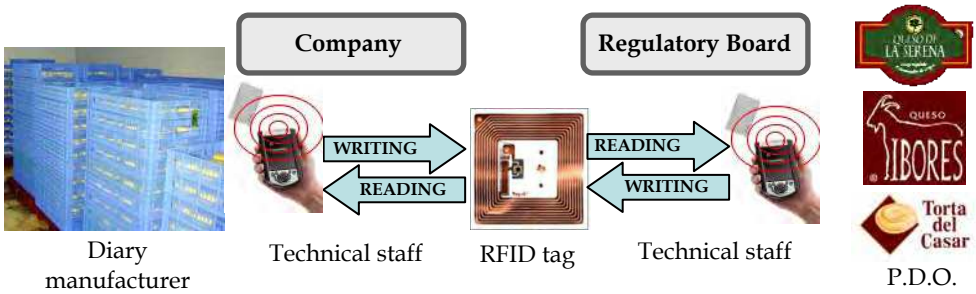


Fig. 3. Use of RFID tags in the integrated system of quality control Company-Regulatory Boards of P.D.O.

2. System implementation

The system developed is similar to that shown in Figure 2. It consists of two complementary systems; one is based on a personal computer (PC) and the other in a PocketPC (PPC). The PocketPC utility was implemented as a complement to the PC due to its portability. The Figure 4 presents a simplified block diagram of the two systems implemented.

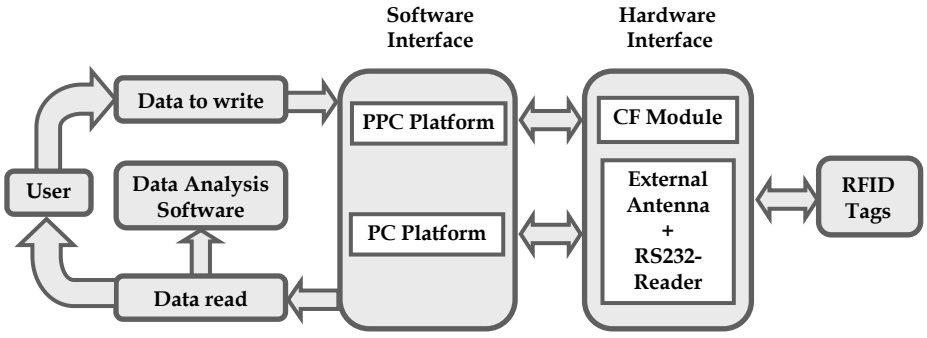


Fig. 4. A simplified block diagram of the two systems implemented

The PC system includes the S6350 midrange reader and the gate antenna series 6000 (Texas Instruments_RFID, 2002). The reader operates at 13.56 MHz and is able to communicate with tags that accomplish ISO 15693 protocol. The communication to the reader is done through a PC serial port, using a RS-232 data transmission protocol, with one start bit, 8 data bits, 1 stop bit and no parity. Several speeds can be selected within the range from 9600 bps to 57600 bps. The PC starts the communication with the reader, through a pair of request/response sequences accomplishing ISO 15693 standard, which establishes the request stream format as well as the fields size. Some of the commands supported by the reader can be used with addressing, i.e., read, write and lock. If addressing is used, the command will be sent to a single tag, and in the other case, the command will be broadcasted to all tags in the visible range of the reader. For example, Figure 5 shows the display of the reader utility after sending the command inventory. As it can be seen, as a response to this command, all transponders visible to the reader appear on the screen.

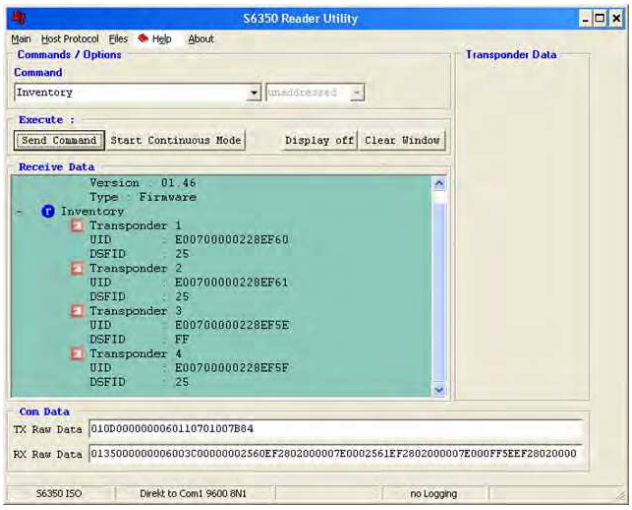


Fig. 5. Display of the reader utility in response to the command inventory

The system is also able to detect errors in such a way that if an error occurs during the communication, the reader will send an error code in the response stream to the PC. Some errors are tags not found in the vision range, a write attempt to a read-only block or an addressing to a non existing block.

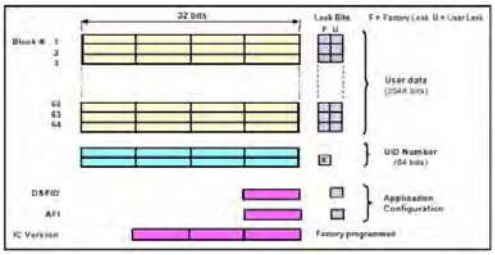
Regarding the PPC system, it consists of:

- PDA with Windows PocketPC 2003® (Hewlett Packard iPAQ, 2003).
- Compact Flash reader with built-in antenna (ACG, 2006).

The hardware interface runs also at 13.56 MHz. Both ASCII and binary transmission modes are supported by the reader, but only ASCII mode has been developed because it simplifies the process. The transmission protocol is ASCII mode at 9600 bps. The PocketPC and the PC version are fully compatible, so that a tag written by one application can be read by the other without problems. The software was implemented with Microsoft® Embedded Visual C++ environment, and the source code includes the library supplied by the reader manufacturer. All the data stored in a tag are accessed and read in just 8 seconds.

Two different types of labels running at 13,56 MHz have been used in this application:
- Individual tags to be used to identify each cheese.
- Batch tags which store all data set and parameters related to its manufacturing process as well as information about the cheeses that belong to it.

Besides, two different rounded-shape tags with different sizes have been tested for individual labels, both on casein plate in order to improve the adherence to the cheese. The smaller one has a diameter of 9 mm and uses the chip I-Code SL2 ICS20 (Philips Semiconductors, 2003). The other one consists of a similar chip and has a size of 20 mm (Labelys, 2007). I-Code chip has a user memory of 128 bytes, divided into blocks of 32x32 bits. Of these 128 bytes, only 108 are addressable bytes (27x32 bits).
The tags HF-I ISO 15963 (Texas Instruments, 2005) have been selected to be utilized as batch labels due to their characteristics of thinness and flexibility. The tags have a 2 kBs user memory organized in 64 blocks x 32 bits as shown in Figure 6 (a).



(a)

Request	Request Code	Request Mode: Inventory	Addressed	Non-Addressed	Select	AFI
ISO 15693 Mandatory and Optional Commands						
Inventory	0x01	✓	–	–	–	✓
Stay Quiet	0x02	–	✓	–	–	–
Read_Single_Block	0x20	✓	✓	✓	✓	✓
Write_Single_Block	0x21	–	✓	✓	✓	–
Lock_Block	0x22	–	✓	✓	✓	–
Read_Multi_Blocks	0x23	✓	✓	✓	✓	✓
Write_Multi_Blocks	0x24	–	–	–	–	–
Select Tag	0x25	–	✓	–	–	–
Reset to Ready	0x26	–	✓	✓	✓	–
Write_AFI	0x27	–	✓	✓	✓	–
Lock_AFI	0x28	–	✓	✓	✓	–
Write DSFID	0x29	–	✓	✓	✓	–
Lock DSFID	0x2A	–	✓	✓	✓	–
Get_System_Info	0x2B	✓	✓	✓	✓	✓
Get_M_Blk_Sec_St	0x2C	✓	✓	✓	✓	✓
TI Custom Commands						
Write_2_Blocks	0xA2	–	✓	✓	✓	–
Lock_2_Blocks	0xA3	–	✓	✓	✓	–

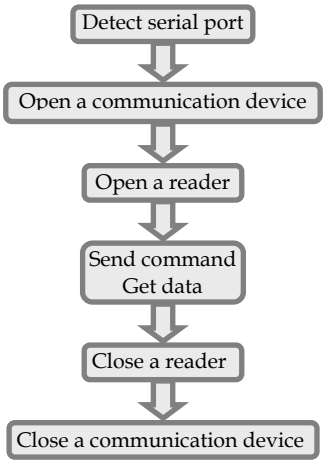
✓: Implemented
–: Not applicable

(b)

Fig. 6. Characteristics of the tags used
(a) Memory organization. (b) List of commands.

Tags can contain read-only data (ROM) and read/write data (R/W). The stored data on blocks can be locked on factory or by user on an irreversible process, so data can not be modified any more. In other cases, tags can be reused for future utilizations.
All the tags have a locked field, the individual identification code UID (Unique IDentifier of the transponder) which is a 64 bits code, provided by the manufacturer and defined in ISO 15693 standard. AFI (Application Family Identifier, such as "transportation"," finance" …)

code allows storing the type of application and DSFID (Data Storage Format IDentifier) the data format. Both of them are 1 byte blocks.
The HF-I tags commands list is seen in Figure 6 (b). Basically, two modes of reading/writing tags are available: single and multiple tag operation. In single tag operation, the first action is to detect a single tag, then the reader identifies the UID, and the subsequent reading/writing commands are referred exclusively to it. On the other hand, in the multiple tag operation the information is broadcasted to all the tags in the reader range.
The PPC utility includes routines for data interpretation and the communication protocol between the compact flash reader and the tags (AGC DLL, 2006). The procedure to establish communication between both devices and start sending commands is shown in Figure 7 (a). As it can be seen, the port where the reader is connected has to be detected and opened. If the port has been opened successfully then the reader is activated and ready to send a set of commands. Figure 7 (b) details the software code that performs the steps previously mentioned.
The "writing tag" command consists of 11 bytes in ASCII mode, so that the first two bytes indicate the address of the block to write, the following 8 bytes are the data to write and the last byte is the NULL or stop chain with all bits to zero. However, the "reading tag" command contains only 3 bytes, which refer to the block number to be read and the NULL byte. Moreover, the reader has a 512 bytes buffer, so once the command is sent and the reader receives the data, the utility can extract the required word from the buffer. The 512 bytes size allows the hardware to read all the tag blocks. Data are sent to the tags by means of a software application. This application is easy-to-use, so that any employee of the



company of Regulatory Boards will be able to use it without difficulties. company or Regulatory Boards will be able to use it without difficulties.

```
// Initialise and open the communication port
       presetSettings* settings=new presetSettings();
       settings->baudRate =460800;
       settings->protocol=0;     // ASCII mode

          char puerto[30];        // Detects the PDA port where the // CF reader is connected

       RDR_DetectSerialPort(puerto);
```

```
if (RDR_OpenComm(puerto,0,settings)==0){  //and check if successful.  // Open the port
                                                    If  //command  returns  a  0  an  error  //has
                                                    occurred
        MessageBox((CString)"Error.",(CString)"Información",MB_OK);
                                                    //no need to specify the first //parameter in
                                                    ASCII mode
}else{
                                                    //If port has been opened //successfully then
                                                    activate //the reader
        RDR_OpenReader(1,6);
        RDR_AbortContinuousRead(); //Stop the continuous
                                                    //readout.Reading only on request
}
```

(a) (b)

Fig. 7. Procedure to establish the communication between the reader and tags
(a) Flow diagram. (b) Software code

The routine includes a "format tag option" which stores zeros in all blocks in order the tag to be reused for future activities. A scheme representing the mode in which data are stored in the tag memory and the data appearance on the PPC screen can be observed in Figure 8. Regarding the data to be recorded in the tags, the writing process has to be optimized in order to store as much as possible cheese production parameters. The fields that will be saved on tags can contain numerical values (temperature, fat, etc.), alphanumerical values (type of milk, manufacturer, Batch, batch qualification, etc.) and data concerning key dates on production (elaboration, reception, ripening, etc.). Numerical data will be codified in binary, differentiating between integer and decimal part. The number of bits required for each part depends on the range of values and the precision used. In some cases, a data manipulation is performed. For example, if a variable varies from 3 to 5, for a value of 4.57, the integer and the decimal part are codified separately.

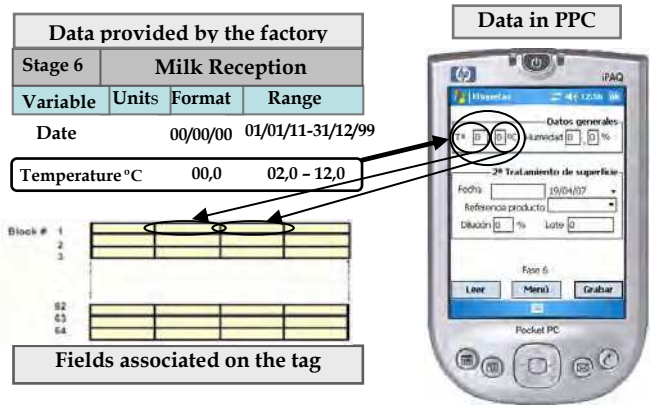


Fig. 8. Data recorded in tag and its representation on the PPC screen

Effective range of integer part has only 3 values (3, 4 and 5), and an offset of 3 is subtracted, so only 2 bits are needed (0 to 2) instead of the 4 bits needed if offset is not considered (0 to 5). On the other hand, alphanumerical values will be stored as a simple database, that is, assigning a numerical value to each data, i.e., type of milk can contain 4 values: "null",

"cow", "goat" and "sheep", that will be linked to numerical values 0, 1, 2 and 3, respectively.
Once all the fields and its associated number of bits are defined, the next step is to arrange the whole tag. The purpose is that each stage of the production process will be associated with a collection of blocks. Around two hundred variables related to the parameters involved in the different phases of the cheese fabrication can be recorded in a tag. Some of them appear in Table 1.

Variable	Range
General Data	
Product Code	1000-2000
Lot	010111-311299
Volume	500 lts-2500 lts
Pieces	50 uds-300 uds
Fit for consumption?	yes/no
Number of tags	000000-999999
Specific data for the different stages	
Reception date	01/01/11-31/12/99
Raw milk supplier	Alphabetical
Tank	Alphanumerical
pH	4,00 upH-7,00 upH
Acidity	13,00 ºD-18,00 ºD
Temperature	02,0 ºC-12,0 ºC
Chemical analysis	
Fat	3,00 %- 8,00 %
Protein matter	2.50 %-7,00 %
Lactose	3,00 %- 6,00 %
sodium chloride	0,80 %-2,20 %
Microbiological analysis	
Listeria monocytogenes	yes/no
Salmonella spp.	yes/no
Staphylococcus aureus	0-20.000 ufc/gr
Yield control	
Lot weight	50,0 kgr-400.0 kgr
Lot yield (Volume/Weight)	4,00-12,00
Average unit weight	750 gr-1400gr
Control of Clients	
Client Reference	Alphanumerical
Order number (units/kgr)	1-300/0,80-400

Table 1. Some parameters stored in the tags

3. Experimental results

The systems have been tested in the industries that collaborate in this work. Previous to place the prototypes in the companies, exhaustive tests were done on tags in laboratory in

order to prove proper working under identical operation conditions than in factory. The simulated conditions were temperature, humidity, biological contamination, acid corrosion, ammoniacal gases and immersion on saline solutions, inhibiting substances, sugars, colorant pigments, preservative substances, oils action (Figure 9 (a)) and mould growing (Figure 9 (b)).

(a)

(b)

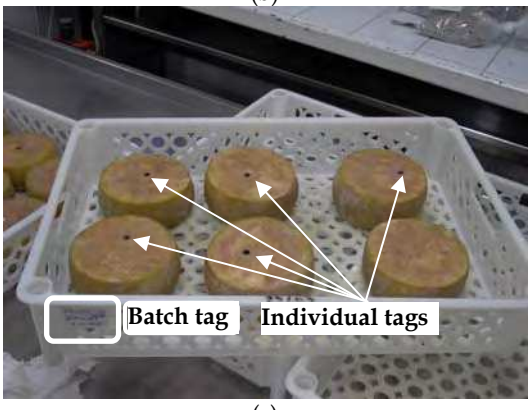
Fig. 9. Test on tags in laboratory
(a) Immersion on saline solution, olive oil and paprika. (b) Mould growing.

Besides, physical tests have been also made which include friction and flexibility because in ripening chambers, cheeses with its corresponding tags are subject to turns, shelving changes, frictions and personnel manipulations. In all these cases, no significant negative effects have been reported in communication with tags, with the exception of data reading with metallic materials in the range of the reader, which reported erroneous reading.
Finally, in order to confirm that tags were suitable to be attached to the products from the start of the fabrication to the end, the tags were placed on the surface of the cheese at the

beginning of the production. As can be seen in Figure 10, which corresponds to photographs taken at different stages of production, both types of tags used as individual labels remained

(a)

(b)



(c)

Fig. 10. Tags in different stages of production

(a) Before molding. (b) After pressing. (c) At the end of production attached to the rind of the cheese until the end of the process without reporting errors in the reading/writing process. Figure 10 also shows the containers with their batch labels.

Regarding the signal range, for the PC application the system is able to read/write tags inside a radius of around 20 cm, whereas the PPC reader has a limited range of around 25 mm, in both cases, enough for our purposes.
Finally, Figure 11 displays the way in which data are updated using the PPC system. The application is user-friendly so that employees of factories in charge of quality control and technical staff of Regulatory Board of P.D.O. responsible for quality certification could use the system easily.

Fig. 11. Data update in cheeses with attached RFID tags

4. Conclusion

Two different systems that perform the reading/writing task with RFID tags in a cheese industry have been implemented. One of them is based on a Personal Computer whereas the other solution uses a PocketPC providing the application with the required portability. The main objective has been to make available to the factory the complete traceability of the products, in individual and by batches mode, as well as to provide the technical staff of Regulatory Boards of P. D. O. with a tool that facilitates the process of quality certification.
The tags have been tested under different conditions of temperature, humidity, acid corrosion, ammoniacal gases and immerse in saline solutions with inhibiting substances, sugars, colorant pigments, preservative substances and oils. Besides, physical tests have been also made which include friction and flexibility. In all the situations, no significant negative effects have been reported in communication with tags, excepting for metallic materials in the range of the reader. Around two hundred variables related to the parameters involved in the different stages of the cheese production can be stored in the tag, which improve considerably the quality and yield control of the production plant.

5. Acknowledgements

This work has been financially supported by the Ministry of Infrastructures and Technological Development of the Government of Extremadura, under Grant PDT05A042 and PDT08A041 with the economic assistance of the European Union (FEDER).

6. References

ACG Multi ISO Plug-In Reader, (2006). ACG Identification Technologies, RDHP-0206P0-02

ACG RFID Reader DLL, (2006). User Manual, Rev 1.0, January 2006

Certification Criteria CC/3, (2005), Requirements to be met by the dairy industry, *Manual of quality of the Regulatory Board of P.D.O.*, Torta del Casar, (4), 1-8, Casar de Cáceres

Certification Criteria CC/4, (2007), Characteristics of the "Torta del Casar" Produced. *Manual of quality of the Regulatory Board of P.D.O.*, Torta del Casar, (5), 1-6, Casar de Cáceres

Coscarón, C.; Gil, M. & Legaz, E. (2007). *Revista Alimentaria*, No. 383, May 2007, 48-55, ISSN 03005755

Decree 1808, (1991) Which governs the indications or marks identifying the batch to which a foodstuff belongs

Decree 217, (2004), Which regulate the identification and registration of staff, facilities and containers involved in the dairy sector, and record the movements of the milk

Finkenzeller, K. (2003). *RFID Handbook: Fundamentals and Applications in contactless smart cards and identification*, John Wiley and Sons, ISBN 0-470-84402-7

Hewlett Packard iPAQ h5550 with Windows Pocket PC, (2003)

Labelys traçabilité, (2007). RFID casein plate

Order 25/4, (1997). Laying down the regulations of the Denomination of Origin "Ibores cheese" and its Regulatory Board

Order 11/1, (1999). Official recognition of the Designation of Origin "Torta del Casar"

Order 9/10, (2001). Adoption of the Rules of the Designation of Origin "Torta del Casar"

Order 6/5, (2002). Ratification of the Rules of the Designation of Origin "Torta del Casar"

Pérez-Aloe, R.; Valverde, J. M.; Lara, A; Carrillo, J. M.; Roa, I. & González, J. (2007). Application of RFID tags for the overall traceability of products in cheese industries, *Proceedings of 1st Annual RFID Eurasia Conference*, pp. 268-272, ISBN 978-975-01566-0-1, Turkey, September 2007, Istanbul

Philips Semiconductors, (2003). I-Code SL2 ICS20, Smart Label IC, Rev. 3.0, January 2003

Regulation 178, (2002). Laying down the principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures relating to food safety

Regulation 1491, (2003). Registration of Protected Designation of Origin "Torta del Casar" in the Register of Protected Designations of Origin and Protected Geographical Indications

Spanish Agency for Food Security (2004). *Guide for the application of traceability in food companies*. Coimán S. L., NIPO 355-04-001-9, Madrid

Texas Instruments_RFID, (2002). HF Reader System Series 6000, S6350 Midrange Reader Module, September 2002

Texas Instruments_RFID, (2002). HF Reader System Series 6000, Gate Antenna, September 2002

Texas Instruments, (2005). Tag-it™ HF-I Plus Transponder Inlays, December 2005

Data Storage

Edited by Florin Balasa

ISBN 978-953-307-063-6
Hard cover, 226 pages
Publisher InTech
Published online 01, April, 2010
Published in print edition April, 2010

The book presents several advances in different research areas related to data storage, from the design of a hierarchical memory subsystem in embedded signal processing systems for data-intensive applications, through data representation in flash memories, data recording and retrieval in conventional optical data storage systems and the more recent holographic systems, to applications in medicine requiring massive image databases.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Raquel Perez-Aloe, Jose M. Valverde, Antonio Lara, Fernando Castano, Juan M. Carrillo, Jose Gonzalez and Isidro Roa (2010). Use of RFID Tags for Data Storage on Quality Control in Cheese Industries, Data Storage, Florin Balasa (Ed.), ISBN: 978-953-307-063-6, InTech, Available from: http://www.intechopen.com/books/data-storage/use-of-rfid-tags-for-data-storage-on-quality-control-in-cheese-industries

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821